

ESRC Macroeconomic Modelling Bureau 1991-95

Report of Research Activities and Results*

1. Background

Macroeconometric models play a key role in the macroeconomic policy-making process. They provide a consistent and comprehensive account of the relevant economic interactions and interdependencies, quantified with reference to historical data. Different models are built for different purposes, however, and not only models but also the problems they address evolve over time, as social and political changes alter the focus of economic attention. Moreover models are built in accordance with an underlying view of the way the world works. Thus different models may provide different estimates of the response of the economy to policy interventions and innovations. It is then important to identify the sources of such disagreement, and to reduce it where possible.

The ESRC Macroeconomic Modelling Bureau was established in 1983 to improve the accessibility of macroeconomic models of the UK economy, to promote general understanding of the properties of these models, their forecasting performance and policy implications, and to undertake comparative and methodological research. The first award covered the period 1983-87, and a second award 1987-91. The present report covers the period of the third award by the Macroeconomic Modelling Consortium, which provided funding at a level that represented approximately one half of the labour input provided by each of the first two awards. During this period the Bureau worked with six models of the UK economy, namely those developed by the three other groups in receipt of Consortium support (London Business School, National Institute of Economic and Social Research, University of Strathclyde), together with two "official" models (those of HM Treasury and the Bank of England) and one private-sector model (Oxford Economic Forecasting).

2. Objectives

The principal aims and objectives of the proposed research, as modified in the light of the Consortium's deliberations, were to

- (a) increase general understanding of the properties and policy implications of models of the UK economy,
- (b) develop and apply techniques for the comparative analysis of models and forecasts, with the aim of highlighting and resolving differences between them,
- (c) arrange conferences and seminars on particular aspects of macroeconomic modelling and research, including the work of the Bureau, and so provide a forum for discussion of modelling issues of general interest.

These objectives have been met by

(a) continuation of the Bureau's series of surveys published in the National Institute Economic Review (see 5.1 below), contributions to other media (sections 4, 6, 7) and continued development and distribution of the PC-Ready Reckoner program (section 6),

(b) a sequence of research studies (section 5),

(c) organising an annual residential conference and other activities (section 4).

3. Methods

The methods used followed and extended those developed under previous awards. Various characteristics and properties of a model, and the results of various model-based exercises, can be used for descriptive and analytic purposes. Any of them can also be used for comparative purposes, given several models, and then it is necessary first to ensure that the comparison is a valid one and secondly to understand, explain, and possibly resolve any differences that emerge.

Complete deposits of the current versions of the models and their associated solution databases were taken on two occasions: in late 1992-early 1993, and in late 1994-early 1995. For three models the solution database corresponds to a forecast published by the model proprietor; in the case of the Treasury, which treats its forecast assumptions as official secrets, the forecast is that of the Ernst and Young ITEM Club, kindly supplied by the Club; in the remaining two cases (Strathclyde, Bank of England), a database for simulation purposes is supplied. The process of implementing these models at Warwick was relatively straightforward although not entirely free of bugs, which were typically resolved by telephone; in one case a fresh deposit was required. Prior to the first deposit it was necessary to transfer all of the Bureau's model solution (SLIM) and associated databank (UPDATE) software from the old IBM 4381 mainframe to the new Warwick Unix system. The availability of some PC-based software eased this transfer, but a considerable amount of rewriting and testing was still required.

Following successful implementation of the models, comparative work begins with a study of overall model properties, in which dynamic multipliers and ready-reckoners are calculated under standardized conditions. This study serves a dual purpose. First, it meets the demand for basic summary information about the models; the results are discussed in 5.1 below. Second, it indicates particular features of the models for more specific research. Having identified the differences of interest in model responses, the source of these differences can be located in the model structure by diagnostic simulations, in which the importance of a particular transmission mechanism is assessed by alternatively switching it off. Sometimes the results point to a basic error or inconsistency which may be readily remedied. Other times particular features of different models represent genuine alternative specifications, which may be subject to econometric evaluation. The sensitivity of overall model properties to improved or revised specifications that emerge from econometric testing may be assessed by observing the impact of the alteration on the comparative simulation results.

It should be emphasized that the model research methods summarized above would be virtually impossible to implement without hands-on access to the models and their databases. The econometric research methods employed are those of standard time-series econometrics as embodied in widely distributed packages such as PC-GIVE and MICROFIT. A further study also used control theory methods as a vehicle for model comparisons and as a subject of comparison in its own right; the results are discussed in §5.2 below.

4. Activities

A two-day residential seminar was held at Warwick each July. The programmes contained between 14 and 16 papers, typically two or three by Bureau members and the remainder by outside speakers. Average attendance was 70. Overseas attendance grew, with participants from the Federal Reserve Board (Washington DC) and the Central Planning Bureau (The Netherlands), for example. The meeting has become a focal point for the modelling community, initially domestic but increasingly international. A workshop participant (see below) from overseas commented that the 1994 meeting was "the best modelling conference I've ever attended".

One Friday afternoon seminar was held at LSE; this activity was then superseded by the Macroeconomic Modelling Workshop series organized by the University of Strathclyde with support from the ESRC Research Seminar Competition.

For three weeks each July the Department of Economics organizes a Summer Research Workshop, with approximately 30 visitors in residence. In 1994 Bureau members played a leading part in the organization of the workshop, on the topic "Econometric modelling of European macroeconomic integration", with support from the ESRC and the European Commission. Whereas the workshop provides time and space for individual and joint research and has just one seminar each day, a "mini-conference" with a full programme is usually held during the workshop, which in particular allows a larger audience to interact with workshop visitors. In the 1994 workshop the Bureau's residential seminar played this role, being held two weeks later than usual to make this possible. The Summer Research Workshop was the subject of a separate report to the ESRC, but it might be noted that a special issue of *Economic Modelling* has subsequently been devoted to papers presented at the Workshop on macroeconomic modelling in the EU periphery.

The Bureau participated in the SPES network of European-based multicountry modellers, and organized its second conference, held at Warwick in March 1992.

Over 25 outside seminar and conference presentations of Bureau research were given; highlights included presentations at "National Econometrics Day", The Netherlands and the Swedish Ministry of Finance, together with the organization of a special session at the Royal Economic Society Annual Conference, 1994.

5. Results

5.1 Comparative properties

As noted above, the Bureau's analysis of the overall properties of models via standard simulation experiments helps fulfil its objective of increasing general understanding of the models while suggesting directions for further research. Such exercises had previously been undertaken annually, but following the reduction of resources now take place only every other year. The results are presented in articles entitled "Comparative properties of models of the UK economy" published in the August issues of the *National Institute Economic Review* in 1993 and 1995.

The 1993 exercise was based on six models and four fiscal policy simulations (changes in government expenditure, income tax, VAT and employers' national insurance contributions) conducted in a common monetary policy setting of unchanged nominal interest rates ("money finance"), together with a simulation of a change in short-term interest rates. A major explanation of several of the observed cross-model differences in estimated policy responses was found to be differences in the modelling of the exchange rate and its relation to domestic and foreign interest rates. Further attention was given to the question of the effects of tax and spending decisions on future levels of government borrowing. It was found that

- (a) the long-run effects on the PSBR can be very different from those in the first year, because of the response of households and firms to the changes in policy;
- (b) the implications of tax changes for wage bargaining, and hence for the sustainable level of unemployment, are crucial to the long-run effects on tax revenue and on spending;
- (c) a very different picture emerges if households and firms anticipate tax changes announced to take effect in the future;
- (d) it is possible that a permanent tax increase now may actually *increase* the PSBR in a few years' time.

The following two years saw important changes in the public and professional debate about macroeconomic policy making, with the objective of monetary policy having shifted from the maintenance of sterling within its ERM bands to the direct control of inflation, and the restoration of the public finances to good order having received increased attention, partly as a result of the Maastricht Treaty conditions. By the time of the second model deposit, several of them reflected these changes. Several now incorporated feedback rules in which nominal interest rates respond to changes in inflation and/or deviations of inflation from its target value. Several models also incorporated fiscal closure rules that ensure the sustainability of policy, in particular ruling out the possibility of an explosion of government debt; none of them had such rules in the previous deposit.

These changes in policy making and policy modelling were also reflected in the 1995 comparison exercise. Two separate pieces of research, described below, had been undertaken in the meantime, on inflation targeting and fiscal closure rules, and a new standardized policy environment was introduced for the 1995 simulation experiments. This reflected the broad objectives of policy - sound public finances and low inflation - by using feedback rules for income tax and interest rates, introducing them where necessary into models that were not already so equipped, but without necessarily imposing the same rules across all models. Thus the objectives and the general nature of the mechanisms to achieve them were common to all models, but not the fine detail of the feedback rules. Five models featured in the exercise, a bug-free version of the Bank of England model not having been received in time, and again five simulation experiments were undertaken: three fiscal policy simulations (the standard government expenditure shock, conducted both with and without the fiscal closure rule in place, and an income tax change) and two monetary policy shocks (changes in the inflation target and foreign interest rates).

Determining interest rates and income tax rates by feedback rules can be seen as endogenizing these variables, rather than treating them as exogenous variables whose values can be freely assigned. Endogenization of these policy instruments nevertheless reflects the structure of the remainder of the models, since the dynamic response of the system under control depends not only on the nature of the control rule but also on the intrinsic dynamics of the uncontrolled system. The major difference in the macroeconomic outcomes across the models is due to differences in the speed of policy response to a deviation from an inflation or PSBR target. This is the critical variable which requires further study - theoretical and empirical - in the context not only of the closure rules used on individual models but also of the design of a standardized, realistic policy environment for use in comparative studies.

5.2 Inflation targeting

A model comparison exercise based on a simple one instrument, one target control problem also allowed comparison across different approaches to the problem, namely the use of feedback control rules or full numerical optimization. Taking the target to be the reduction of inflation and the instrument to be the short-term interest rate represented a simple characterization of the current monetary policy regime. To ensure a valid comparison, however, the objective was specified as the achievement of an inflation rate one per cent per annum lower than in the base forecast. Specifying an absolute target of say 2.5 per cent when inflation in the base forecast differs across models would contaminate the comparison since the policy instrument would have a different amount of work to do for this reason alone.

The major distinction between the results for the four models studied is in the nature of the time path for interest rates that is required to reduce inflation, irrespective of the different control techniques that deliver these time paths. This is associated with a distinction between the models concerning the treatment of expectations, particularly in respect of exchange rate behaviour. Only the model that adopts the rational expectations

hypothesis comes close to satisfying the theoretical proposition that the inflation rate should be changeable without altering any real magnitude. In particular, following a period of adjustment, the nominal interest rate should fall broadly in line with inflation leaving the real interest rate unchanged in the medium term.

5.3 Sustainability and fiscal closure rules

In collaboration with Dr Jeremy Bray MP, working with the Treasury model, and representatives of LBS, NIESR and OEF, the Bureau undertook a comparative analysis of the sustainability of the current policy regime and its ability to meet the Maastricht conditions for convergence to EMU. Writing in early 1992, it was shown that the maintenance of sterling's central rate in the ERM was likely to lead to current account deficits at a level which could induce loss of confidence, in turn putting pressure on the exchange rate, although the inflation, government deficit and interest rate conditions could be met by 1996. This work received much press attention at the time.

The requirement that debt explosions do not occur, that is, that the government remains solvent, imposes an intertemporal budget constraint on the government, which can be modelled via a closure rule which adjusts an instrument of fiscal policy to achieve stability. Examples of closure rules were previously mostly found in multicountry models. Their introduction has a greater impact on simulation results in models where forward-looking, model-consistent expectations play an important role, since in these models the long-run effects of exogenous shocks have a stronger influence on short-run behaviour.

Fiscal closure rules were implemented on the two models in the 1993 comparison exercise with forward-looking expectations. Our rule adjusts the basic rate of income tax in response to deviations of the PSBR/GDP ratio from its target (base-run) value. The parameter governing the size of the tax-rate response is chosen to ensure that the debt/GDP ratio has stopped rising after fifteen years. The results show that the multiplier effects of increased government expenditure are smaller in the controlled than in the uncontrolled cases. The short-run differences are more substantial the more important are the expectations variables.

A further issue concerns the timing of the implementation of the closure rule. In the recent Brookings multicountry model comparisons a delay in the adjustment formed part of the desired experimental design, although not all model proprietors followed the instructions. The importance of such a delay is illustrated using the Murphy model of the Australian economy, which has forward-looking expectations in financial markets, together with a closure rule as part of its normal structure. Following a fiscal expansion of 1 per cent of GDP, delaying the implementation of the closure rule for four years results in an initial tax-rate increase that is 2 percentage points larger than when the closure rule operates continuously. Postponing the adjustment thus implies a path for the tax rate which forward-looking agents may not find credible, as suggested by Christopher Sims in his comments on the Brookings exercise. Overall, closure rules that respect the intertemporal budget constraint and operate continuously should form part of the

experimental design, and these were introduced in the 1995 comparison exercise, as noted above.

5.4 Consumer behaviour

Research into empirical models of consumer behaviour was undertaken by the Bureau with the support of HM Treasury. This was motivated by the large errors in forecasting consumption in the late 1980s and early 1990s, which were a major contribution to the poor performance in forecasting overall economic developments. Some large-scale models were revised following their failure to predict the boom of the late 1980s, and an important question was whether these developments help them to explain the downturn of the early 1990s, which again was not well predicted.

The theoretical basis of all the models considered is the life-cycle model of Modigliani. Two recent developments are considered. One is the model of Blanchard, in which the original infinite-horizon assumption is replaced by the assumption that consumers face a constant probability of death, and the second is the wealth or liquidity constraints model of Hall and Mishkin. An updated empirical assessment of a hybrid of these two approaches originally estimated by Weale is also undertaken.

The statistical models have error-correction representations, describing a process of adjustment towards a long-run target relationship, which in turn draws on the idea of cointegration among a group of economic time series. Accordingly, cointegration analysis is first undertaken, and a single cointegrating vector relating total consumption expenditure, disposable income and total (housing and financial) wealth is found, with no structural breaks over the last twenty years. Examination of the dynamic models then focuses on parameter stability, forecasting performance and cross-model comparisons. Parameter stability tests show that equations for total consumers' expenditure are less prone to failure in the late 1980s than those for non-durable consumption. In their forecasts, however, none of the models fully captures the fall in consumption expenditure after 1990. In direct model comparisons, encompassing tests provide no conclusive results, in the face of the high degree of similarity of the models considered.

Analysis of Weale's model provides empirical support for the role of wealth or liquidity constraints. Moreover, recursive analysis suggests that consumption by constrained individuals as a proportion of the total has not varied significantly. While this finding may suggest that financial deregulation had no effect, it may also arise because its effect was offset by increased expectations of future income growth. While the research provides a sharper focus on these hypotheses, it is as yet not possible to distinguish between them.

The forecast comparisons were subsequently extended to include neural network models, in collaboration with a member of Warwick Business School. The main question is whether the neural network technology, possibly highly non-linear, can extract any more from the given data than the econometric approach. For the neural network model builder an additional issue is the performance of the methods with relatively short data series.

It is found that the neural network models describe the decline in the growth of consumption since the late 1980s as well as, but no better than, the four econometric specifications included in the exercise. The results suggest that the log-linear econometric specification is adequate for modelling expenditure provided that the information required to produce an acceptable model is contained in the given data set. This is not the case in some of the models, those which include terms in the unemployment rate among the explanatory variables performing better than those which do not. The neural network model can filter out irrelevant inputs by giving them low weight, and is shown to be robust in small samples. When all twenty-five explanatory variables from the econometric models are supplied to the network, it performs as well as the best single model. Thus, whichever, approach is adopted, it is the skill of choosing the menu of explanatory variables that determines final success.

5.5 Aggregation and homogeneity of prices

The different objectives of the UK model proprietors have resulted in models which vary considerably in the amount of detail they provide. Those involved in analyzing policy need to judge the effects of policy changes on the different sectors of the economy, while those outside this process are possibly more interested in the overall view and not the detail. The treatment of the price sector in the models reflects these different requirements. Although the amount of detail that the models provide about prices varies, the principle that changes in costs should be fully reflected by changes in prices is accepted. The importance of the long-run neutrality of prices is not a new issue, although the recent concentration on the supply side has refocused attention on this matter.

We studied the contrasting methods by which the central aggregate price variable is constructed. Despite agreement that homogeneity of prices is a desirable model property counterexamples exist. These departures from the benchmark framework are illustrated by considering an exchange rate shock, which should with full homogeneity be transmitted through the price-wage system into a similar rise in the domestic price level. However, the removal of existing non-neutralities does not guarantee that the benchmark result is achieved within the available simulation horizon. Variant simulations indicate the importance of adjustment lags.

The aggregation literature contains criteria for selection between aggregate and disaggregate models, but these take no account of the extra information that is available in the disaggregate approach. Typically the model that describes the aggregate variable with least error is preferred. An historical tracking exercise is used to compare the accuracy with which models with different levels of aggregation describe the same price index. Theory suggests that a more disaggregate approach is needed to model an aggregate variable that has many differently behaving components. In practice, however, this approach can lead to greater specification error as all relationships have to be established from the data, and an intermediate case is preferred. Changes in the relative importance of different expenditure categories over time has led to changes in the weights with which the different component prices enter the final index. In some models errors are introduced when the weights used in the current version are inappropriate for

earlier years. It is necessary to model the time variation in the weights if the components move in different directions, both in historical tracking exercises and in policy simulations.

5.6 Price determination and the business cycle

Output price inflation in the UK has recently fallen to historically very low levels. Forecasts produced with the price equations of several models underestimate even these low levels of inflation. A Bureau study aimed to explain the causes of this forecasting failure and to develop an alternative model for output prices. While the focus at the macroeconomic policy level is on the impact of policy tightness on inflation, price fixing is for the most part the prerogative of private sector firms, and the importance of the overseas competitive environment for domestic firms is examined. In particular, it is argued that the recent forecast errors are due to an exclusive focus on domestic developments. The structure of domestic demand may also have an impact on output prices.

The output price equations of six models are examined, five of which include a measure of capacity utilization. In the models which employ backward-looking expectations, this variable appears central to the recent forecasting failure, since the substantial fall in capacity utilization in the recent recession was not matched by the corresponding fall in prices that the models consequently predicted. An alternative model is proposed where inflation in the short run and output prices in the long run are determined by the mark-up of prices over unit costs and two other variables. The first is a measure of demand overseas and the second is the ratio of investment to total demand. These new variables, apart from improving forecast performance, demonstrate that the relationship between price setting and the business cycle depends on the source of any cyclical shock.

5.7 Fundamental Equilibrium Exchange Rates

The Fundamental Equilibrium Exchange Rate (FEER) is that value of the real exchange rate that is consistent with macroeconomic equilibrium. An early study calculated the FEER implied by each of three models. The paths of the FEERs that emerge are found to be similar despite cross-model differences in trade elasticities. Historical comparisons between the FEER and the actual real exchange rate show that the start and end of the 1980s are both times when the actual rate lies above the FEER, reflecting the tight monetary policy designed to reduce inflation. During the middle part of the decade - a time of stable inflation - the actual exchange rate tracks the FEER.

Writing in late 1991, the models all agreed that the FEER was above the actual real exchange rate. Together with the fixing of the nominal exchange rate in the ERM this implied that to reach equilibrium a sustained period during which UK inflation falls below that of our trading partners would be required. Although the gap between the actual and fundamental rates at the start of the 1980s was of similar magnitude to that at the end, convergence to equilibrium in the middle of the decade was mainly achieved by a fall in the nominal exchange rate. With ERM entry this possibility was ruled out and

any convergence must be achieved through improvements in price competitiveness, which the low elasticities in the three models suggest need to be substantial to improve the trade balance.

5.8 Multicountry models

The Bureau completed its comparative simulation analysis of European-based multicountry models early in the period of the award. This was undertaken for a SPES network of model proprietors funded by the European Commission, and represented an earlier style of "hands-off" model comparison, since the simulation results were provided by the model proprietors. A further proposal submitted to the Commission with Bureau participation was unsuccessful. Subsequently the Bureau was successful in its proposal to undertake a pilot multicountry model comparison project as part of the ESRC Global Economic Institutions Research Programme. The project is funded by a separate award over the period 1 July 1994-30 June 1996, and follows the Bureau's established research methods.

6. Outputs

The RAPID database return includes publications on the research topics described above and comprises 5 books, 21 journal articles, 7 book chapters and 16 discussion papers. The Discussion Paper series includes Bureau research papers in the pre-publication stage, as is common practice, together with relevant papers by other researchers, particularly those who have no other convenient outlet for their work. Publication lags imply that a few publications that appeared during the period of this award relate to research undertaken under the preceding award; likewise, further publications are "forthcoming" in 1996.

The PC-Ready Reckoner program was updated periodically and continued to be widely used. It received a favourable review in the *Computer Shopper* magazine, following which several requests were received from rather less usual sources. Having been initially distributed on disk (at the cost of the disk), it is now also available through e-mail.

The Bureau's *Newsletter* continued to be distributed regularly. It contained information about seminars and conferences, Bureau research and other activities, and other items of interest to the macro-modelling community. The average circulation was approximately 500 copies.

Information about the Bureau is available on the Internet through World Wide Web pages. These enable anyone in the world with a suitable computer to examine the list of Bureau publications, see a demonstration of PC-Ready Reckoner and read the *Newsletter*. In an average month over three hundred people visit the pages.

7. Impacts

The research results have fed back into model development work by the model proprietors, as acknowledged most recently, for example, at the presentation to HM

Treasury Academic Panel of the new Treasury model. The research has been the subject of press comment and radio interviews, and has also provided the basis for several letters to the press on topical issues.

The Bureau received a commendation from the assessors for the Partnership Trust Prize in Economics, 1995. The submission for the competition was led by Mr K.G. Knight, Senior Lecturer in Economics, who has developed in collaboration with the Bureau and British Steel a version of the PC-Ready Reckoner program which allows users to explore the implications of macroeconomic developments for business conditions in the UK steel market.

The high standing of the Bureau was reflected in various ways: in the number of visitors received, for visits ranging from one day to one year; in the granting of "host laboratory" status and four HCM research training fellowships by the European Commission; in the invitation to the Director to edit the *Macroeconometric Modelling* volume in the International Library of Critical Writings in Econometrics series published by Edward Elgar, and to publish a volume of his collected papers, nine of which describe Bureau research, most jointly authored with Bureau staff. During this period he was elected a Fellow of the British Academy and a member of the Council of the Econometric Society, and continued to serve as a member of HM Treasury Academic Panel.

8. Future research priorities

The Bureau received an award in the Macroeconomic Modelling Consortium's Phase 4, covering the period 1995-99. It continues to pursue comparative research on large-scale macroeconomic modelling, together with research on substantive economic issues which is distinguished from other research on these issues by adopting an encompassing approach and by taking account of full-system responses. Other activities described above also continue to develop.

*This report is presented using the eight standard headings specified in the Guidelines on the Preparation of the End of Award Report, Section 2.6.
